

WHAT IS CLAIMED IS:

- 1        1. A system for exchanging data between an object-oriented system and a  
2 relational system having tables defining a relational model, the system comprising:  
3            at least one object class definition defining an object model;  
4            an object relational mapping data structure defining a mapping between the  
5            object model and the relational model, the object relational mapping data  
6            structure produced from a declarative ORM Specification based on an  
7            ORM grammar;  
8            an exchange unit for translating data from the object model to the relational  
9            model and for translating data from the relational model to the object  
10          model.  
1        2. The system of claim 1, wherein the exchange unit further comprises:  
2            an object call processing unit having inputs and outputs for receiving object calls  
3            and beginning the translation of the object calls, an input and an output of  
4            the object call processing unit coupled to the object-oriented system;  
5            a mapping unit having inputs and outputs for performing the object-relational  
6            mapping according to the object relational mapping specification in  
7            response to signals from the object call processing unit, the mapping unit  
8            having inputs coupled to the object class definition, the object relational  
9            mapping data structure, and input and outputs the object call processing  
10          unit; and

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11        a database interface unit having inputs and outputs, for retrieving and storing  
12                data in the relational system, the inputs and outputs coupled to the  
13                relational system and the mapping unit.

1        3.      The system of claim 2 wherein the object call processing unit intercepts  
2                Application Programming Interface (API) level calls for object manipulation and  
3                executes the API level calls using the mapping unit.

1        4.      The system of claim 1, wherein the exchange unit further comprises:  
2                an object relational mapping specification defining a mapping between the object  
3                model and the relational model, the object relational mapping  
4                specification including a plurality of a declarative ORM grammar  
5                statements; and  
6                an ORM Data Structure creation unit having inputs and an output for producing  
7                the object relational mapping data structure, the inputs of the ORM Data  
8                Structure creation unit coupled to receive the object class definition, the  
9                object relational mapping specification, and the database interface unit,  
10               the output of the ORM Data Structure creation unit coupled to the input of  
11               the mapping unit for providing the object relational mapping data  
12               structure.

1        5.      The system of claim 1, further comprising a schema generator, the schema  
2                generator having inputs and outputs for generating a file of commands applicable on  
3                the relational system that implement the object call, the input of the schema generator

4 coupled to the object class definition and the object relational mapping data structure,  
5 the output of the schema generator coupled to the relational system.

1           6. The system of claim 5, wherein the schema generator further comprises:  
2           an ORM Data Structure creation unit having inputs and an output for producing  
3           the object relational mapping data structure, the inputs of the ORM Data  
4           Structure creation unit coupled to receive the object class definition and  
5           the object relational mapping specification;  
6           a relational schema statements generation unit having an input and an output,  
7           the input of the relational schema statements generation unit coupled to  
8           the output of the ORM Data Structure creation unit for receiving the object  
9           relational mapping data structure, the relational schema statements  
10          generation unit producing a file of statements that will produce the  
11          relational schema in the relational system; and  
12          a relational schema statements application unit having an input and an output  
13          for applying statements to the relational system, the input of the relational  
14          schema statements application coupled to the output of the relational  
15          schema statements generation unit for receiving the file of statements that  
16          will produce the relational schema in the relational system, the output of  
17          the relational schema statements application unit coupled to the input of  
18          the database interface unit for applying the statements on the relational  
19          system.

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- 1        7. The system of claim 1, wherein the relational system is a relational  
2 database management system.
- 1        8. The system of claim 7, further comprising:  
2            a plurality of RDBMS Tables stored in the relational system, the plurality of  
3            RDBMS Tables setting forth the organization and structure of the data in  
4            the relational model in addition to describing certain functionality  
5            provided by the relational model; and  
6            a plurality of ORMMetadata Tables stored in the relational system, the plurality  
7            of ORMMetadata Tables storing additional object relational specifications.
- 1        9. The system of claim 1 further comprising a schema reverse-engineering  
2 unit for creating object class definitions and an object relational mapping specification  
3 using a database schema.
- 1        10. The system of claim 9, wherein the schema reverse-engineering unit  
2 further comprises:  
3            an ORM template specification containing names of tables to be used for  
4            generating object class definitions;  
5            database metadata inquiry unit for accessing the relational system to retrieve  
6            metadata including a schema for the relational model and information  
7            about the object model, the database metadata inquiry unit coupled to the  
8            relational system; and

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9           reverse engineering ORM structure creation unit for producing an object  
10          relational mapping data structure from metadata, the reverse engineering  
11          ORM structure creation unit coupled to the output of the database  
12          metadata inquiry unit to receive the metadata and coupled to receive the  
13          ORM template specification.

1           11.       The system of claim 10, wherein the schema reverse-engineering unit  
2          further comprises an ORM specification generation unit for producing an ORM  
3          specification from the object relational mapping data structure, the ORM specification  
4          generation unit coupled to the object relational mapping data structure.

1           12.       The system of claim 10, wherein the schema reverse-engineering unit  
2          further comprises an object class definitions generation unit for producing the object  
3          class definitions from the object relational mapping data structure, the object class  
4          definitions generation unit coupled to the object relational mapping data structure.

1           13.       The system of claim 1, further comprising a named sequence generator for  
2          generating persistently unique sequence numbers, the named sequence generator  
3          having inputs and outputs, the named sequence generator coupled to the relational  
4          system for and coupled to the object-oriented system by the exchange unit.

1           14.       The system of claim 1, wherein the object relational mapping data  
2          structure includes a mapping for a stored procedure executable by an engine in the  
3          relational system, the stored procedure being invokable by an application program

4 using the exchange unit and creating an object with a value returned by executing the  
5 stored procedure.

1           15. The system of claim 1, wherein the system further comprises a security  
2 unit having inputs and outputs for determining whether a user can use the ORM  
3 Specification and a scope for use of the ORM Specification, the security unit coupled to  
4 control access to the object relational mapping data structure and the exchange unit.

1           16. A method for generating an object relational mapping data structure, the  
2 method comprising the steps of:

3           determining whether an object relational mapping file has been specified;  
4           if an object relational mapping file has been specified, using an object relational  
5           mapping specification identified by the object relational mapping file as  
6           the identified object relational mapping specification;  
7           if an object relational mapping file has not been specified, determining an ORM  
8           identification name, retrieving an object relational mapping specification  
9           corresponding to the ORM identification name from a relational database,  
10          and using the retrieved object relational mapping specification as the  
11          identified object relational mapping specification; and  
12          creating an object relational mapping data structure using the identified object  
13          relational mapping specification.

1           17. The method of claim 16 wherein the step of determining an ORM  
2 identification name further comprises the steps of:

3 determining whether an ORM identification name has been specified;  
4 using the ORM identification name specified if an ORM identification name has  
5 been specified; and  
6 using a default ORM identification name specified if an ORM identification name  
7 not has been specified.

1 18. A method for generating object relational mapping data structures from

2 an object relational mapping specification includes the steps of:

3 retrieving an object relational mapping specification;

4 creating an instance of a plurality of data structures defining a mapping between

5 an object model and a relational model;

6 overriding default mappings using a SQL map specification;

7 using additional specifications to create additional data structures;

8 retrieving Metadata from a database to enhance the plurality of data structures;

9 matching class information for object-oriented model with the plurality of data

10 structures;

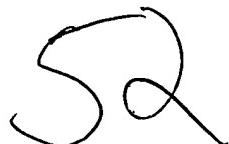
11 generates SQL statements for each class; and

12 generates inserts and update statements to apply SQL statements to the database.

1 19. The method of claim 18, wherein the step of creating an instance of a

2 plurality of data structures includes the steps of:

3 creating an instance of DatabaseInfo;

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4 creating an instance of Tableinfo and ClassInfo for each class specification;  
5 creating instance of CollectionClassInfo for each collection specification; and  
6 creating the instances of AttribInfo for each ClassInfo.

1 20. The method of claim 19, wherein the step of using additional  
2 specifications to create additional data structures includes the steps of:  
3 using primary-key and reference-key specifications to create instances of  
4 ReferenceKeyinfo; and  
5 using the relationship specification to create instances of ComplexAttributeInfo.

1 21. The method of claim 20, wherein the step of matching class information  
2 comprises the step of matching AttribInfo with ColumnInfo.

1 22. A method for generating relational schema from an ORM specification  
2 and object class definitions, the method comprising the steps of:  
3 retrieving an object relational mapping specification;  
4 retrieving an object class definitions;  
5 creating an instance of a plurality of data structures defining a mapping between  
6 an object model and a relational model;  
7 overriding default mappings using a SQL map specification;  
8 using additional specifications to create additional data structures; and  
9 adding relational information to the data structures for each primitive and  
10 embedded attribute of the object-oriented model.

1        23. The method of claim 22, wherein the step of creating an instances of a  
2        plurality of data structures includes the steps of:  
3              creating an instance of DatabaseInfo;  
4              creating an instance of Tableinfo and ClassInfo for each class specification;  
5              creating an instance of CollectionClassInfo for each collection specification; and  
6              creating the instances of Attribinfo for each ClassInfo.

1        24. The method of claim 23, wherein the step of using additional  
2        specifications to create additional data structures includes the steps of:  
3              using primary-key and reference-key specifications to create instances of  
4              ReferenceKeyinfo; and  
5              using the relationship specification to create instances of ComplexAttributeInfo.

1        25. The method of claim 23, wherein the step of adding adds ColumnInfo in  
2        Tableinfo for each primitive and embedded attribute of each ClassInfo.

1        26. The method of claim 23, wherein the step of generating statements for  
2        producing and modifying tables in relational database includes the steps of:  
3              generating a create table statement and primary key constraints statement in a  
4              CREATE file for each Tableinfo;  
5              generating unique key and referential key constraint statements in an ALTER file  
6              for each ClassInfo; and  
7              generating alter table drop constraint statements and drop table statements in a

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8           DROP file for each ClassInfo.

1           27.     The method of claim 26, wherein the step of executing the generated  
2        statements on the database includes the step of executing the DROP, CREATE and  
3        ALTER files to modify the database.

1           28.     A method for generating an ORM specification and object class definitions  
2        from a database schema, the method comprising the steps of:  
3                  generating object relational mapping data structures using an ORM template  
4                  specification;

5                  performing at least one metadata query to retrieve information for the object  
6                  relational mapping data structures;

7                  generating an object class definition using the object relational mapping data  
8                  structures; and

9                  creating an ORM Specification using object relational mapping data structures.

1           29.     The method of claim 28 wherein the step of generating object relational

2        mapping data structures comprises the steps of:

3                  creating an instance of DatabaseInfo; and

4                  creating an instance of ClassInfo and TableInfo for each class in the ORM

5                  Template Specification.

1           30.     The method of claim 28 wherein the step of performing at least one  
2        metadata query includes the steps of:

3 performing a metadata query and creation of ColumnInfo and AttributeInfo in  
4 the corresponding ClassInfo for each instance of TableInfo;  
5 performing a metadata query to get the PrimaryKeyInfo for each ClassInfo;  
6 performing a metadata query to get the foreign key information and create the  
7 corresponding ComplexAttributeInfo for each instance of ClassInfo;

1 31. The method of claim 28 wherein the step of creating an ORM Specification  
2 using object relational mapping data structures is done using the DatabaseInfo and all  
3 the instances of ClassInfo.

1 32. A method for responding to an object call using a mapping unit, the  
2 method comprising the steps of:  
3 determining the type of object call;  
4 setting up an access plan data structure according to flags settings;  
5 creating a command statement for accessing relational system; and  
6 issuing the command statement on relational system;

1 33. The method of claim 32 further comprising the step of processing the data  
2 from the relational system to provide it to the object-oriented system.

1 34. The method of claim 32 wherein the step of determining the type of object  
2 call includes the step of determining whether the object call is a query.

1 35. The method of claim 32 wherein the step of setting up access plan data  
2 structure according to flags settings includes the step of setting up the access plan data

3 structure according to the query flags and query details in order to access referenced  
4 objects.

1 36. The method of claim 33 wherein the step of setting up access plan data  
2 structure according to flags settings includes the step of setting up the access plan data  
3 structure as per insert flags and insert details for accessing referenced objects.

1 37. The method of claim 32 wherein the step of creating command statement  
2 for accessing relational system further comprises the steps of:  
3 retrieving a base SELECT statement from ClassInfo;  
4 testing whether any predicate has been specified; and  
5 translating a specified predicate and appending the predicate as a WHERE  
6 clause, if a predicate has been specified;

1 38. The method of claim 37 wherein the step of issuing the command  
2 statement on relational system includes issuing the SELECT statement including a  
3 WHERE clause, if any, against a database of the relational system.

1 39. The method of claim 38 further comprising the step of:  
2 determining whether more rows are available from the database;  
3 if more rows are available from the database,  
4 fetching a next row and creating an instance of a top-level object;  
5 setting attribute values from corresponding column values;  
6 creating required foreign key entries and associating them with target  
7 class structures;

8 determining whether there are query objects from the subclasses;  
9 if there are additional query objects from the subclasses, repeat the steps of  
10 creating command statement for accessing relational system and issuing  
11 the command statement on relational system for the objects of subclasses;

1 39 10. The method of claim 39 wherein the step of processing the data from the  
2 relational system to provide it to the object-oriented system includes the steps of:  
3 creating a SELECT statement and a WHERE clause using the foreign keys for  
4 each referenced target class;  
5 retrieving rows and creating target objects and linking them with referencing  
6 complex attributes;  
7 creating a foreign key entry for each complex attribute of the target class; and  
8 returning a list of top-level objects to the application.

Sub Obj 1 41. The method of claim 32 wherein the step of creating command statement  
2 for accessing relational system further comprises the steps of:  
3 retrieving an INSERT statement from ClassInfo;  
4 preparing the INSERT statement for the current connection to the database; and  
5 finding the value for each AttribInfo and binding it with the column position for  
6 each AttribInfo.

1 34 12. The method of claim 41, wherein the step of issuing the command  
2 statement on relational system includes issuing the INSERT statement to store top-level

3 objects in the relational system.

1 ~~35~~<sup>34</sup> 43. The method of claim ~~42~~, wherein the step of issuing the INSERT statement  
2 to store top-level objects in the relational system, further comprises the steps of:  
3 determining whether there are non-null referenced objects to be inserted,  
4 creating an additional INSERT statement for each non-null referenced objects if  
5 there are non-null referenced objects to be inserted; and  
6 issuing the additional INSERT statements.

1 ~~46~~<sup>41</sup> A method for object streaming comprising the steps of:  
2 beginning a new transaction;  
3 generating a query call to a database exchange unit for a plurality of objects;  
4 returning the predetermined number (X) of objects;  
5 processing the returned objects;  
6 determining whether more objects are to be retrieved through the current stream  
7 of objects;  
8 retrieving and processing an additional number (m) of objects if more objects are  
9 to be retrieved through the current stream of objects;  
10 generating a query close to the database exchange unit; and  
11 committing the transaction to the database.

1 ~~46~~<sup>44</sup> 45. The method of claim ~~41~~ for object streaming further comprising the steps  
2 of:

3 determining a query context (QC) for streaming;  
4 invoking a query operation on the query context for a predetermined number (X)  
5 of objects;  
6 saving in the query context, the query cursor for the table of top-level class  
7 objects;  
8 initiating a query processing to fetch the predetermined number (X) of objects;  
9 and  
10 saving the query context for this session.

~~42-46.~~ <sup>40</sup> The method of claim ~~41~~ wherein the step of retrieving and processing an

additional number (m) of objects further comprises the steps of:

3 generating a "query fetch" call for the additional number (m) of objects to the  
4 database exchange unit;  
5 invoking a query operation on the saved query context for the additional number  
6 (m) of objects;  
7 retrieving the query cursor saved in the query context;  
8 processing the query to fetch the additional number (m) of objects;  
9 returning the additional number (m) of objects; and  
10 processing the returned additional number (m) of objects.